How dinosaur blood vessels are preserved through the ages

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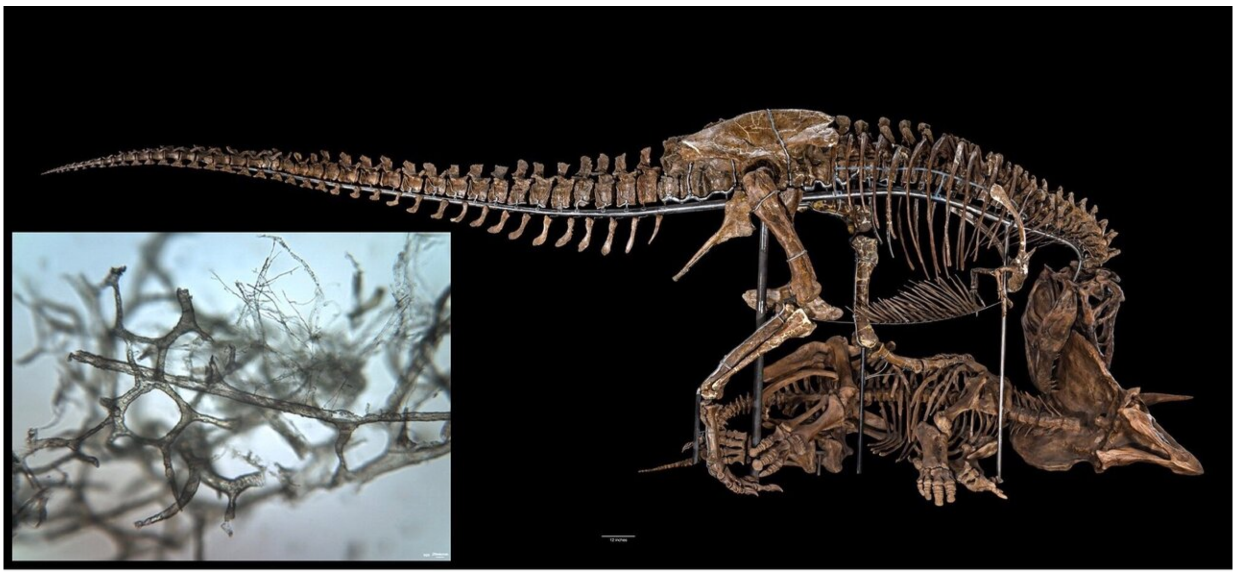

In order to take these mesmerizing microscopy images, the team carefully demineralized small bits of T. rex bone to liberate the preserved vessel tissue inside. The sample used in this study came from the femur of the famous, nearly complete fossil specimen known as “the Nation’s T. rex,” which is currently on display at the Smithsonian National Museum of Natural History. Credit: Boatman et al. and Smithsonian Institute

A team of scientists led by Elizabeth Boatman at the University of Wisconsin Stout used infrared and X-ray imaging and spectromicroscopy performed at Berkeley Lab's Advanced Light Source (ALS) to demonstrate how soft tissue structures may be preserved in dinosaur bones—countering the long-standing scientific dogma that protein-based body parts cannot survive more than 1 million years.

In their paper, now published in *Scientific Reports*, the team analyzed a sample from a 66-million-year-old Tyrannosaurus rex tibia to provide evidence that vertebrate blood vessels—collagen and elastin structures that don't fossilize like mineral-based bone—may persist across geologic time through two natural, protein-fusing "cross-linking" processes called Fenton chemistry and glycation.

First, the scientists used imaging, diffraction, spectroscopy, and immunohistochemistry to establish that structures present in the sample are indeed the animal's original collagen-based tissue. Then, Berkeley Lab co-authors Hoi-Ying Holman and Sirine Fakra respectively performed synchrotron radiation-based Fourier-transform infrared spectromicroscopy (SR-FTIR) to examine how the cross-linked collagen molecules were arranged, and X-ray fluorescence (XRF) mapping to analyze the distribution and types of metal present in T. rex vessels.

"SR-FTIR takes images and spectra of the same sample, and so you can reveal the distribution of protein-folding patterns, which helps to identify the possible cross-linking mechanisms," said Holman, director of the Berkeley Synchrotron Infrared Structural Biology (BSISB) Imaging Program. Fenton chemistry and glycation are both non-enzymatic reactions—meaning they can occur in deceased organisms—that are driven by the iron present in the body.

"The XRF microprobe revealed the presence of finely crystalline goethite, a very stable iron oxyhydroxide mineral, on the vessels that likely contributed to the preservation of organic molecules," said Fakra, an ALS research scientist.

The authors believe that the cross-linking reactions they found evidence of, combined with the protection offered from being surrounded by dense mineralized bone, can explain how original soft tissues persist.

More information: Elizabeth M. Boatman et al. Mechanisms of soft tissue and protein preservation in Tyrannosaurus rex, *Scientific Reports* (2019). DOI: 10.1038/s41598-019-51680-1

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